Prevalences of positive skin test responses to 10 common allergens in the US population: Results from the Third National Health and Nutrition Examination Survey

Samuel J. Arbes, Jr, DDS, MPH, PhD,[a] Peter J. Gergen, MD, MPH,[b] Leslie Elliott, MPH, PhD,[a] and Darryl C. Zeldin, MD[a] *Research Triangle Park, NC, and Bethesda, Md*

Background: Allergy skin tests were administered in the second and third National Health and Nutrition Examination Surveys (NHANES II and III) conducted in the United States from 1976 through 1980 and 1988 through 1994, respectively.
Objectives: This study estimated positive skin test response rates in NHANES III and identified predictors of one or more positive test responses. Comparisons with NHANES II were also made.
Methods: In NHANES III, 10 allergens and 2 controls were tested in all subjects aged 6 to 19 years and a random half-sample of subjects aged 20 to 59 years. A wheal-based definition of a positive test response was used.
Results: In NHANES III, 54.3% of the population had positive test responses to 1 or more allergens. Prevalences were 27.5% for dust mite, 26.9% for perennial rye, 26.2% for short ragweed, 26.1% for German cockroach, 18.1% for Bermuda grass, 17.0% for cat, 15.2% for Russian thistle, 13.2% for white oak, 12.9% for *Alternaria alternata*, and 8.6% for peanut. Among those with positive test responses, the median number of positive responses was 3.0. Adjusted odds of a positive test response were higher for the following variables: age of 20 to 29 years, male sex, minority race, western region, old homes, and lower serum cotinine levels. For the 6 allergens common to NHANES II and III, prevalences were 2.1 to 5.5 times higher in NHANES III.
Conclusions: The majority of the US population represented in NHANES III was sensitized to 1 or more allergens. Whether the higher prevalences observed in NHANES III reflect true changes in prevalence or methodological differences between the surveys cannot be determined with certainty. (J Allergy Clin Immunol 2005;116:377-83.)

Key words: *Allergens, allergic sensitization, allergy skin test, epidemiology, NHANES II, NHANES III, survey*

Over the last 2 or more decades, rates of asthma have increased in the United States and worldwide, although there is some evidence that asthma rates might have peaked.[1-3] One of the most important risk factors for asthma is sensitization to one or more allergens. The National Center for Health Statistics included allergy skin testing in the second and third National Health and Nutrition Examination Surveys (NHANES II and III), which were conducted from 1976 through 1980 and 1988 through 1994, respectively, to estimate and monitor the prevalence of allergic sensitization in the United States.

Although skin test results from NHANES II have been published,[4] a comprehensive summary of skin test results from NHANES III has not been published, nor has a comparison between NHANES II and III data been published. The primary objectives were to estimate rates of positive skin test responses in NHANES III and to identify predictors of a positive test response to 1 or more allergens. A secondary objective was to compare positive skin test response rates between NHANES II and III; however, methodological differences between the 2 surveys, which this article describes in detail, provide challenges for comparing and interpreting rate differences between the 2 surveys.

METHODS

NHANES II and III

NHANES II and III were two in a series of population-based surveys conducted by the National Center for Health Statistics to determine the health and nutritional status of the US population. Both surveys used a complex design to sample the civilian, noninstitutionalized population. In NHANES II, questionnaires and medical examinations were administered to 20,322 individuals aged 6 months to 74 years, whereas in NHANES III, 31,311 individuals aged 2 months to 90 years were interviewed and examined.

Allergy skin testing in NHANES II and III

Prick-puncture allergy skin testing was performed in NHANES II and III; however, there were important differences in age eligibility,

From [a]the Laboratory of Respiratory Biology, Division of Intramural Research, National Institute of Environmental Health Sciences, National Institutes of Health, Research Triangle Park, and [b]the Division of Allergy, Immunology, and Transplantation, National Institute of Allergy and Infectious Diseases, National Institutes of Health, Bethesda.

This analysis of National Health and Nutrition Examination Survey (NHANES III) data was funded by the National Institute of Environmental Health Sciences and the National Institute of Allergy and Infectious Diseases.
Received for publication March 1, 2005; revised April 25, 2005; accepted for publication May 12, 2005.
Available online July 15, 2005.

Reprint requests: Darryl C. Zeldin, MD, NIEHS/NIH, PO Box 12233, MD D2-01, Research Triangle Park, NC 27709. E-mail: zeldin@niehs.nih.gov.

0091-6749
doi:10.1016/j.jaci.2005.05.017

Abbreviations used
NHANES II: The second National Health and Nutrition Examination Survey
NHANES III: The third National Health and Nutrition Examination Survey

medical exclusion criteria, number and types of allergens tested, standardization of allergen extracts, and reading times for the reactions. Overviews of the allergy skin test protocols for both surveys are presented here; however, details of the protocols can be found elsewhere.[5,6]

In NHANES II, prick-puncture allergy skin tests to 8 allergens (house dust, cat, dog, *Alternaria alternata*, mixed giant-short ragweed, oak, perennial ryegrass, and Bermuda grass) and 2 controls (positive and negative) were administered to all subjects aged 6 to 74 years. Each of the allergens was commercially available and US Food and Drug Administration licensed, but none was standardized. A standardized extract is one for which a reference standard for potency exists. The positive control was histamine phosphate, and the negative control was 50% glycerol saline. Subjects in 48 of the 64 primary sampling units were tested with a histamine base concentration of 0.1 mg/mL, a less than optimal concentration, whereas the rest were tested with the optimal concentration of 1.0 mg/mL.[7] Lengths and widths of wheals (raised area in the middle of the reaction) and flares (reddish area around the wheal) were measured at 10 and 20 minutes. Subjects with a history of allergy to cats, dogs, or ragweed were not initially tested for those allergens. At the 10-minute reading, if the subject reacted to fewer than 3 of the remaining allergens, then dog, cat, and ragweed were tested on the other arm. If 3 or more responses were positive, then only ragweed was tested on the other arm.

In NHANES III, prick-puncture allergy skin tests to 10 allergens (Table I) and 2 controls (positive and negative) were administered to all subjects aged 6 to 19 years and a random half-sample of subjects aged 20 to 59 years. The positive control was histamine phosphate (concentration is not published), and the negative control was 50% glycerol saline.[8] Only house dust mite, cat, and short ragweed allergens were standardized (personal communication with Paul Turkeltaub, MD, December 2, 2004). Lengths and widths of wheals and flares were measured after 15 minutes (± 5 minutes). Subjects were medically excluded from skin testing if they usually did not have trouble breathing in their chest or lungs but were having trouble breathing at the time of the examination, although not from a cold; if they usually had trouble breathing in their chest or lungs and had more trouble breathing at the time of the examination; if they had a severe response to allergen skin testing previously; or if they had severe eczema or infection on both arms.

For comparisons between NHANES II and III, prevalences of positive skin test reactions in NHANES II were estimated for the 6 allergens and ages (6-59 years) common to both surveys. The 6 allergens were cat, ragweed (mixed giant and short in NHANES II and short in NHANES III), perennial rye, oak (oak in NHANES II and white oak in NHANES III), Bermuda grass, and *A alternata*.

Definition of a positive skin test response

For our analyses of NHANES II and III skin test data, we considered an allergen-specific skin test response positive if the skin test panel was valid and the difference between the mean of the wheal's length and width for the allergen-specific test and the negative control was at least 3 mm. A skin test panel was considered valid if the difference between the mean wheal diameters of the positive and negative controls was at least 1 mm. For NHANES II results, measurements from the 20-minute reading were used.

TABLE I. Prevalences of positive skin test responses among the US population aged 6 to 59 years represented in NHANES III

Allergen tested	Percentage (SE)
Indoor allergens	
Dust mite	27.5 (1.02)
German cockroach	26.1 (0.82)
Cat	17.0 (1.00)
At least one indoor allergen	43.0 (1.12)
Outdoor allergens	
Perennial rye	26.9 (0.88)
Short ragweed	26.2 (1.03)
Bermuda grass	18.1 (0.81)
Russian thistle	15.2 (0.92)
White oak	13.2 (0.78)
Alternaria alternata	12.9 (0.69)
At least one outdoor allergen	40.0 (1.22)
Food allergen: peanut	8.6 (0.51)
At least one indoor or outdoor allergen	53.9 (1.02)
At least one of any type	54.3 (1.00)

In NHANES II, 11,769 of the 16,204 subjects who were age eligible for skin testing were aged 6 to 59 years, and of those, 11,062 had a wheal-based result for the 6 allergens common to both surveys. Of the 11,062 subjects, 7230 had a valid skin test panel, 3024 had an invalid panel, and 808 were missing a positive control result. The NHANES II analysis was limited to the 7230 subjects; however, a secondary analysis was conducted without regard to the valid panel criterion (n = 11,062).

In NHANES III, there were 12,106 age-eligible subjects, and of those, 10,863 participated in skin testing, 174 were excluded for medical reasons, and 1069 refused or were unavailable for testing. Of the 10,863 subjects, 10,841 had a result for all 10 allergens, and of those, 10,508 had a valid skin test panel, 332 had an invalid panel, and 1 subject was missing a positive control result. The NHANES III analysis was limited to the 10,508 subjects.

Statistical analyses

Percentages (with SEs) of the population with positive skin test responses were estimated among the populations aged 6 to 59 years represented by the surveys. Sociodemographic or medical examination variables were assessed as potential predictors of one or more positive skin test responses in NHANES III. The complete list can be viewed in Table E1 in the Online Repository in the online version of this article at www.mosby.com/jaci. Potential predictors were evaluated first with χ^2 statistics and then with multivariable logistic regression by using a backward selection process. The process began with all potential predictors in the model and ended with variables at a P value of .050 or less. Education, rather than poverty/income ratio, was modeled as an indicator of socioeconomic status because the latter had a large number of missing values, and serum cotinine level was modeled in place of smoker in the home because serum cotinine level is a biomarker for tobacco smoke exposure. Two-way interactions between sex, age, and race-ethnicity were evaluated and adjusted for the other predictors in the model. Only interactions significant at the .050 level were reported.

Statistical analyses were conducted with SAS Version 9.1 (SAS Institute, Cary, NC) or SUDAAN Release 9.0 (RTI International, Research Triangle Park, NC) software. All percentages and odds

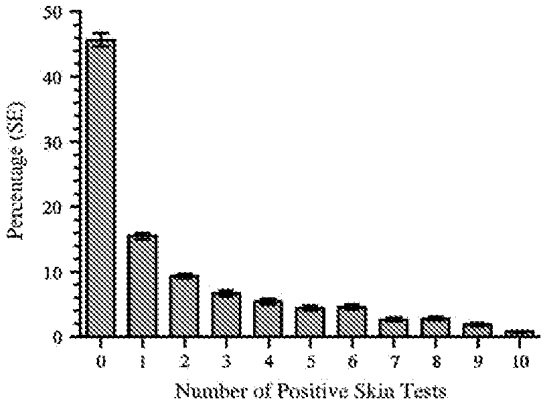

FIG 1. Percentage of the US population aged 6 to 59 years (NHANES III) by numbers of positive skin test responses.

ratios reported in this article were weighted to represent population estimates, and all SEs were adjusted for the complex survey design. Numbers of subjects reported in this article are unweighted.

TABLE II. Distribution of positive skin test responses by allergen classification among the US population aged 6 to 59 years represented in NHANES III

	Percentage (SE)	
Allergen type	Among the total population	Among the population with positive test responses
Indoor only*	13.7 (0.55)	25.3 (1.13)
Outdoor only†	9.7 (0.68)	17.9 (1.26)
Peanut only	0.3 (0.11)	0.6 (0.20)
Indoor and outdoor only	22.2 (1.10)	41.0 (1.57)
Indoor and peanut only	0.2 (0.06)	0.3 (0.11)
Outdoor and peanut only	1.2 (0.18)	2.3 (0.32)
Indoor, outdoor, and peanut	6.9 (0.50)	12.6 (0.88)
None	45.7 (1.00)	–
Total	100.0 (0.00)	100.0 (0.00)

*House dust mite, cat, or German cockroach.
†Short ragweed, perennial rye, *Alternaria alternata*, Bermuda grass, Russian thistle, or white oak.

RESULTS

NHANES III: Prevalences of positive skin test responses

Table I shows the prevalences of positive skin test responses among the US population aged 6 to 59 years. More than half of the population had positive test responses to one or more allergens. The highest prevalences were for dust mite, rye, ragweed, and cockroach, and the lowest prevalence was for peanut. A positive test response to at least 1 indoor allergen was slightly more common than a positive test response to at least 1 outdoor allergen (43.0% vs 40.0%), even though twice as many outdoor allergens were tested.

The percentage of the population with a positive test response decreased as the number of positive test responses increased from 1 to 10 (Fig 1). A solitary positive skin test response was seen in 15.5% (SE = 0.48) of the total population and 28.7% (SE = 0.95) of the population with positive test responses. The 2 most common solitary reactions were to cockroach (4.3% [SE = 0.42] of the total population) and dust mite (4.2%, SE = 0.24). The prevalences of a solitary reaction to the other allergens ranged from 0.10% to 1.70% of the total population. The mean and median numbers of positive test responses among those with positive test responses were 3.5 (SE = 0.06) and 3.0, respectively.

Table II shows how positive skin test responses—classified as indoor, outdoor, and peanut—were distributed among the total US population and among those with positive test responses. Among those with positive test responses, 41% reacted to a combination of indoor and outdoor allergens (but had negative test responses to peanut). A positive test response to peanut alone was quite rare (0.6%), as were positive test responses to indoor allergens and peanut (0.3%) and outdoor allergens and peanut (2.3%).

NHANES III: Predictors of 1 or more positive test responses

The independent predictors of 1 or more positive test responses were sex, age, race-ethnicity, census region, home construction year, and serum cotinine level. The distributions of these predictors in the US population and their adjusted odds ratios are shown in Table III. The distributions of all tested predictors and their bivariate associations with each of the 10 allergen skin tests can be found in Table E1 in the Online Repository in the online version of this article at www.mosby.com/jaci.

Age was bivariately associated with each allergen test (Table E1). The prevalence of 1 or more positive test responses, as well as the adjusted odds ratio, increased from the first decade of age to the second, peaked in the third decade, and then decreased through the sixth decade (Table III).

For each allergen tested, male subjects were more likely than female subjects to have positive test responses (Table E1). The adjusted odds of having 1 or more positive test responses were 1.6 times greater in male subjects (Table III). The odds ratio for sex did not differ by age (*P* value for sex-age interaction term = .518); however, it did differ by race-ethnicity (*P* value for sex-race interaction term = .027). With the sex-race interaction term in the model (model not shown), the adjusted odds ratios comparing male subjects with female subjects were 1.6 (95% CI, 1.3-2.0) for non-Hispanic whites, 1.4 (95% CI, 1.1-1.8) for non-Hispanic blacks, 1.1 (95% CI, 0.9-1.4) for Mexican Americans, and 2.0 (95% CI, 1.1-3.8) for others.

Race-ethnicity was bivariately associated with a positive test response to 7 of the 10 allergens (Table E1). Compared with non-Hispanic whites, the adjusted odds of having 1 or more positive test responses were greater for each of the other 3 race-ethnicity categories (Table III). However, as mentioned in the previous paragraph,

TABLE III. Prevalences and odds ratios for the independent predictors of 1 or more positive skin test responses among the US population aged 6 to 59 years represented in NHANES III

Predictor	Percentage (SE)	Adjusted* odds ratio (95% CI)	Wald F test, *P* value
Age (y)			
6-9	45.6 (2.19)	1.0 (reference)	
10-19	55.5 (1.33)	1.7 (1.3-2.1)	
20-29	60.0 (1.79)	2.1 (1.6-2.8)	
30-39	56.5 (1.96)	1.8 (1.4-2.4)	
40-49	50.5 (2.71)	1.5 (1.1-2.0)	
50-59	49.1 (2.70)	1.4 (1.0-1.8)	<.001
Sex			
Female	49.2 (1.23)	1.0 (reference)	
Male	59.4 (1.21)	1.6 (1.4-1.8)	<.001
Race-ethnicity			
Non-Hispanic white	51.3 (1.17)	1.0 (reference)	
Non-Hispanic black	62.0 (1.26)	1.6 (1.4-1.9)	
Mexican American	57.1 (1.28)	1.2 (1.0-1.4)	
Other	64.0 (2.85)	1.5 (1.2-2.0)	<.001
Census region			
South	50.8 (1.40)	1.0 (reference)	
West	58.0 (1.51)	1.3 (1.1-1.6)	
Northeast	57.9 (2.78)	1.2 (0.9-1.8)	
Midwest	52.8 (2.57)	1.1 (0.9-1.5)	.042
Year home constructed			
1974 to present	53.1 (1.40)	1.0 (reference)	
1946-1973	52.1 (1.60)	0.9 (0.8-1.1)	
Before 1946	59.4 (1.69)	1.3 (1.1-1.6)	.002
Cotinine (ng/mL)			
0.035-0.100	56.9 (2.17)	1.0 (reference)	
0.100-10.00	55.4 (1.63)	0.9 (0.7-1.1)	
10.00-1080.00	51.0 (1.48)	0.7 (0.5-0.9)	.012

*Adjusted for each variable in the table.

there was a significant interaction between sex and race-ethnicity. Among female subjects, the adjusted odds ratios for race-ethnicity (with non-Hispanic whites as the referent) were 1.8 (95% CI, 1.4-2.2) for non-Hispanic blacks, 1.4 (95% CI, 1.2-2.7) for Mexican Americans, and 1.4 (95% CI, 0.9-2.1) for others. Among male subjects, those adjusted odds ratios were 1.5 (95% CI, 1.2-1.8), 1.0 (95% CI, 0.8-1.2), and 1.7 (95% CI, 1.2-2.5), respectively.

Census region was bivariately associated with tests to the outdoor allergens ragweed, rye, grass, and thistle (Table E1). For 1 or more positive test responses, the adjusted odds ratio was lowest for the south and highest for the west (Table III).

Home construction year was bivariately associated with a positive test response to dust mite, cockroach, ragweed, and peanut (Table E1). The prevalence of one or more positive test responses, as well as the adjusted odds ratio, was greatest in the oldest homes (Table III).

Serum cotinine levels were bivariately associated with 4 of the 6 outdoor allergens (Table E1); however, for those allergens, the lowest cotinine level was associated with the highest prevalence of a positive test response. That same pattern remained in the adjusted model for 1 or more positive test responses (Table III).

Comparisons between NHANES II and III

The prevalences in NHANES II for positive test responses to the 6 allergens and ages (6-59 years) common to both surveys were 12.5% (SE = 0.74) for ragweed, 11.9% (SE = 0.62) for rye, 5.8% (SE = 0.54) for oak, 5.2% (SE = 0.49) for Bermuda grass, 4.5% (SE = 0.29) for *A alternata*, and 3.1% (SE = 0.32) for cat. The NHANES III prevalences for those 6 allergens were 2.1 to 5.5 times higher (Table I), and the NHANES III population was much more likely to react to at least 1 of the 6 allergens (41.9% [SE = 1.23] vs 21.8% [SE = 0.94]). As shown in Fig 2, rates of positive test responses were consistently higher in NHANES III than in NHANES II at each age group.

For both surveys, the prevalences without the valid-panel criterion were systematically less, although only slightly less. For example, the rate for a positive test response to 1 or more of the 6 allergens decreased from 41.9% to 41.4% in NHANES III and 21.8% to 19.6% in NHANES II.

DISCUSSION

The main finding of this study was that 54.3% of the population represented by NHANES III had 1 or more positive skin test responses to 10 common allergens. With the limited number of allergens tested, this might be an underestimation of the prevalence of allergic sensitization in the US population. On average, an individual with a positive test response reacted to 3 to 4 allergens, and most with positive test responses reacted to a combination of indoor and outdoor allergens as opposed to indoor, outdoor, or peanut allergens alone. For each of the 6 allergens tested in both NHANES II and III, the prevalence of a positive test response was higher in NHANES III at each decade of age.

Even though we analyzed positive skin test response rates for the allergens and ages common to both surveys, there were differences between the surveys that could not be controlled, such as differences in medical exclusion criteria, in reading times of the reactions, in the histamine concentrations for the positive controls, and in the quality of the allergen extracts. It would seem doubtful that differences in medical exclusion criteria, reading times, and histamine concentrations would have contributed significantly to the differences in rates because only a small percentage of subjects were excluded for medical reasons in each survey, reading times overlapped somewhat, and results remained essentially the same irrespective of whether the histamine control was used in the definition of a positive test response. One methodological difference that could potentially explain the differences in positive skin test response rates is the potency of the allergens used. Only the cat and ragweed allergens tested in NHANES III were standardized, and without standard-

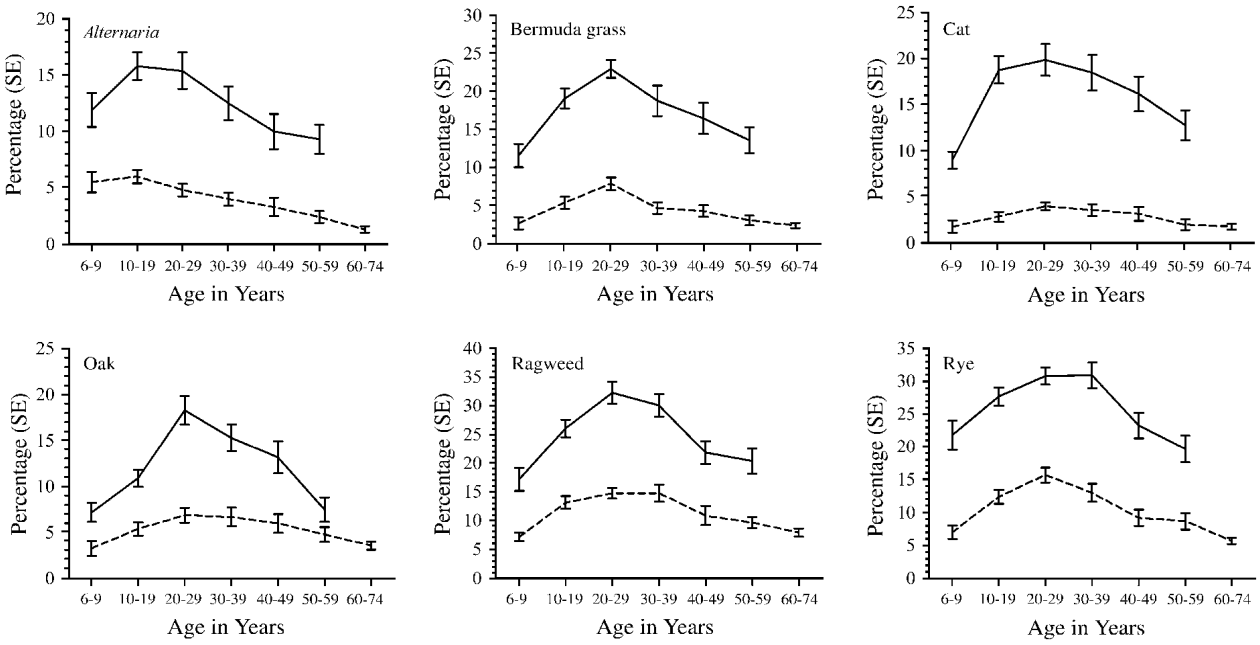

FIG 2. Age-specific comparisons of positive skin test response rates for the 6 allergens tested in NHANES II (*dashed lines*) and NHANES III (*solid lines*).

ization, it cannot be assumed that the potencies of the allergens were the same between surveys. In fact, unstandardized allergen extracts can vary greatly in their potencies.[9]

The relative potencies of the allergens used in these 2 surveys are unknown, and because of this, it cannot be stated with any certainty that the increases in positive skin test response rates observed between NHANES II and III were due to true increases in reactivity in the US population. However, we would like to present 2 arguments that support true increases.

First, potency between unstandardized allergens could be greater, less, or the same, and it would seem unlikely that the potency would have been systematically greater for all 6 of the NHANES III allergens. An example of the variability one might expect between allergen preparations can be found within NHANES II itself. Within NHANES II, complete panels of allergens were purchased from 2 different manufacturers, and subjects were tested with one panel or the other.[7] In a comparison of positive skin test response rates between these 2 panels of allergens, Gergen and Turkeltaub[7] found that one panel gave higher rates for 3 allergens, lower rates for 1 allergen, and similar rates for 4 allergens; however, none of the absolute differences was greater than 4.7%. Second, the increases seen between NHANES II and III are consistent with reports from other countries, such as Japan,[10] the United Kingdom,[11] and Denmark.[12]

In NHANES III, sex, race-ethnicity, age, census region, home construction date, and serum cotinine level were independent predictors of 1 or more positive skin test responses. Age was the strongest independent predictor of 1 or more positive skin test responses, with rates peaking at age 20 to 29 years. In cross-sectional studies it is often difficult to determine whether age effects are real or are due to a cohort effect (ie, the effect of capturing a high-risk cohort at a point in time). However, the age-specific comparisons between NHANES II and III (Fig 2) provide strong evidence that the prevalence of allergic sensitization truly peaks in the third decade of life. If the NHANES III finding had been due to a cohort effect, then NHANES II rates would have peaked at a younger age.

The prevalence of 1 or more positive test responses was higher among male than female subjects, and the prevalence was higher for male subjects at each decade of life. In the general population, male subjects have higher levels of serum IgE than female subjects at any given age,[13] but whether sex influences sensitization primarily through a genetic or an environmental pathway is not known. The higher prevalence of allergic sensitization among male subjects at any age is in contrast to the pattern seen with asthma. For asthma, the prevalence is greater in male subjects during childhood but greater in female subjects during the teenage and adult years.[14] This contrast suggests that factors other than allergic sensitization are responsible for the sex-related shift in asthma prevalence observed at or near puberty.

Compared with non-Hispanic whites, the odds of having 1 or more positive skin test responses were increased for the other 3 race-ethnicity categories. For NHANES II, Gergen et al[4] reported that the age-adjusted prevalence of 1 or more positive test responses was higher in blacks than whites; however, the difference was not statistically significant. In a study of allergic sensitization among children

in NHANES III, Stevenson et al[15] argued that race or ethnicity differences in sensitization likely reflect differences in environmental exposures rather than genetics. In finding race-ethnicity a strong predictor of positive test responses to dust mite, cockroach, and *A alternata*, those authors reasoned that the association was most likely to be due to differences in housing and community environments, which would lead to differences in allergen exposures.

For census region and home construction date, the allergen-specific results suggest that these predictors affect sensitization primarily through an environmental pathway. Census region was bivariately associated with positive test responses to outdoor allergens only, which likely reflects geographic differences in exposures to those allergens. Consistent with the NHANES III results, Gergen et al[4] reported that positive test response rates in NHANES II were lowest in the south. Older homes were bivariately associated with positive test responses to the indoor allergens dust mite and cockroach. In the National Survey of Lead and Allergens in Housing, a representative survey of US housing, it was shown that older homes had higher levels of dust mite, cockroach, and mouse allergens than newer homes.[16,17]

Higher serum cotinine levels predicted lower prevalences of 1 or more positive test responses. Active smoking has been associated with increased serum levels of total IgE; however, the published literature on the relationship between either active or passive smoking and skin test response positivity is inconclusive.[18,19] Chronic tobacco smoke exposure can suppress the immune system and impair host defenses,[20] which could potentially lead to lower sensitization rates; however, smoke avoidance among persons with allergies and asthma would also lead to lower rates.

Two potential predictors worth discussing that did not remain in the final prediction model were the presence of an indoor cat and the presence of an indoor dog. The role of pet exposure in the cause of allergic sensitization and disease is controversial. One limitation to this cross-sectional analysis was the inability to assess the timing of exposures and the development of allergic sensitization, which could be an explanation for the lack of association with indoor cat and dog. Interestingly, the presence of an indoor cat was not associated with a positive skin test response to cat allergen. One potential explanation for this null result could be the pervasiveness of cat allergen in US homes. In the National Survey of Lead and Allergens in Housing, 99% of homes with an indoor cat and 56% of homes without an indoor cat had cat allergen levels that exceeded the proposed threshold for allergic sensitization.[21] In epidemiologic studies the more widespread an exposure is within a population, the more difficult it becomes to demonstrate its effects.[22] Another potential explanation could be cat avoidance among persons who are sensitized to cats.

In conclusion, the majority of the US population represented in NHANES III was sensitized to 1 or more allergens. Although it cannot be definitively concluded that the increases in positive skin test response rates observed between NHANES II and III represent an increase in the reactivity of the US population, such an increase would be consistent with studies from other countries. In NHANES 2005-2006, total and allergen-specific IgE levels are being measured in all subjects, along with levels of indoor allergens in their homes.

We thank Drs Stephanie London and Donna Baird (Epidemiology Branch, National Institute of Environmental Health Sciences) for providing helpful comments during the preparation of this manuscript.

REFERENCES

1. Mannino DM, Homa DM, Akinbami LJ, Moorman JE, Gwynn C, Redd SC. Surveillance for asthma—United States, 1980-1999. MMWR Surveill Summ 2002;51:1-13.
2. Robertson CF, Roberts MF, Kappers JH. Asthma prevalence in Melbourne schoolchildren: have we reached the peak? Med J Aust 2004;180:273-6.
3. Verlato G, Corsico A, Villani S, Cerveri I, Migliore E, Accordini S, et al. Is the prevalence of adult asthma and allergic rhinitis still increasing? Results of an Italian study. J Allergy Clin Immunol 2003;111:1232-8.
4. Gergen PJ, Turkeltaub PC, Kovar MG. The prevalence of allergic skin test reactivity to eight common aeroallergens in the U.S. population: results from the second National Health and Nutrition Examination Survey. J Allergy Clin Immunol 1987;80:669-79.
5. National Health and Nutrition Examination Survey III. Training manual for allergy component. Available at: http://www.cdc.gov/nchs/data/nhanes/nhanes3/cdrom/nchs/manuals/train.pdf. Accessed November 9, 2004.
6. National Center for Health Statistics (U.S.). Public use data tape documentation: allergy skin testing: tape number 5309: National Health and Nutrition Examination Survey, 1976-80. Hyattsville (MD): US Department of Health and Human Services, Public Health Service, National Center for Health Statistics; 1986.
7. Gergen PJ, Turkeltaub PC. National Center for Health Statistics (US). Percutaneous immediate hypersensitivity to eight allergens, United States, 1976-80. Washington (DC): US Department of Health and Human Services Public Health Service, National Center for Health Statistics; 1986.
8. Plan and operation of the Third National Health and Nutrition Examination Survey, 1988-94. Series 1: programs and collection procedures. Vital Health Stat 1 1994;(32)1-407.
9. Gleich GJ, Leiferman KM, Jones RT, Hooton ML, Baer H. Analysis of the potency of extracts of June grass pollen by their inhibitory capacities in the radioallergosorbent test. J Allergy Clin Immunol 1976;58:31-8.
10. Nakagomi T, Itaya H, Tominaga T, Yamaki M, Hisamatsu S, Nakagomi O. Is atopy increasing? Lancet 1994;343:121-2.
11. Sibbald B, Rink E, D'Souza M. Is the prevalence of atopy increasing? Br J Gen Pract 1990;40:338-40.
12. Linneberg A, Nielsen NH, Madsen F, Frolund L, Dirksen A, Jorgensen T. Increasing prevalence of specific IgE to aeroallergens in an adult population: two cross-sectional surveys 8 years apart: the Copenhagen Allergy Study. J Allergy Clin Immunol 2000;106:247-52.
13. Barbee RA, Halonen M, Lebowitz M, Burrows B. Distribution of IgE in a community population sample: correlations with age, sex, and allergen skin test reactivity. J Allergy Clin Immunol 1981;68:106-11.
14. Asthma Prevalence, Health Care Use and Mortality, 2000-2001. Available at: http://www.cdc.gov/nchs/products/pubs/pubd/hestats/asthma/asthma.htm. Accessed April 29, 2003.
15. Stevenson LA, Gergen PJ, Hoover DR, Rosenstreich D, Mannino DM, Matte TD. Sociodemographic correlates of indoor allergen sensitivity among United States children. J Allergy Clin Immunol 2001;108:747-52.
16. Arbes SJ Jr, Cohn RD, Yin M, Muilenberg ML, Burge HA, Friedman W, et al. House dust mite allergen in US beds: results from the First National Survey of Lead and Allergens in Housing. J Allergy Clin Immunol 2003;111:408-14.

17. Cohn RD, Arbes SJ Jr, Yin M, Jaramillo R, Zeldin DC. National prevalence and exposure risk for mouse allergen in US households. J Allergy Clin Immunol 2004;113:1167-71.
18. Burrows B, Halonen M, Lebowitz MD, Knudson RJ, Barbee RA. The relationship of serum immunoglobulin E, allergy skin tests, and smoking to respiratory disorders. J Allergy Clin Immunol 1982;70:199-204.
19. Strachan DP, Cook DG. Health effects of passive smoking. 5. Parental smoking and allergic sensitisation in children. Thorax 1998;53:117-23.
20. Sopori ML, Kozak W. Immunomodulatory effects of cigarette smoke. J Neuroimmunol 1998;83:148-56.
21. Arbes SJ Jr, Cohn RD, Yin M, Muilenberg ML, Friedman W, Zeldin DC. Dog allergen (Can f 1) and cat allergen (Fel d 1) in US homes: results from the National Survey of Lead and Allergens in Housing. J Allergy Clin Immunol 2004;114:111-7.
22. Rose G. Sick individuals and sick populations 1985. Bull World Health Organ 2001;79:990-6.